# INNOVATIVE TEACHING-LEARNING SYSTEM: CDIO INITATIVES IN USTP

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## ABSTRACT

This paper presents the Innovative Teaching-Learning System (ITLS) framework for the CDIO initiatives of the University of Science and Technology of Southern Philippines (USTP). It is composed of two parts: 1) CDIO initiatives under the ITLS framework implemented through the Center for Innovative Teaching and Learning (CITL) 2) A faculty's reflections and burning questions on experiential learning activities for software engineering courses leading to the transition into the workforce The Center for Innovative Teaching-Learning (CITL) concretizes the ITLS Objectives, through intensive faculty training programs on curriculum review, course delivery monitoring and assessment, and innovative teaching-learning strategies including active and experiential learning, design thinking, and virtual learning. The second part of this paper is a study on the employment of CDIO initiatives at the classroom level. It discusses the challenges and possible strategies related to determining and planning experiential learning activities and assessments in large classes and time-limited meetings. One of the strategies applied was designing experiential learning activities that are real-world problem-based and client-partnered, providing the computer engineering students with actual experiences in software development. Reflection and burning questions were the two methods used to assess the students involved in experiential projects. These were used in determining the following: if the students used the principles and theories learned from the classroom; how they handled simple to complex problems; how it enhanced their skills and knowledge; and how their involvement affected their client. The students were then assessed after they finished the degree in terms of their work history and responsibilities. The study shows that the appropriate design of experiential learning activities will enable students to find better job opportunities in the software development area.

## KEYWORDS

Innovative Teaching Learning System (ITLS); Center for Innovative Teaching and Learning, (CiTL); Integrated Learning Experiences, Active and Experiential Learning; Reflection; Burning Questions; Learning Assessment; Innovative Teaching-Learning Strategy

## I. THE INNOVATIVE TEACHING-LEARNING SYSTEM (ITLS)

The University of Science and Technology (USTP) has set up an innovative teaching and learning system that is aligned with its charter (RA 10919) provisions, the OBE framework, and the CDIO approach. Current trends in education advocate a shift from a teaching- or instruction-centered paradigm in higher education to one that is learner- or student-centered within a lifelong learning framework. A learner- or student-centered paradigm in higher education entails a shift from a more input-oriented curricular design based on the description

of course content to an outcomes-based education in which the course content is developed in terms of learning outcomes. (CHED CMO No. 37 Series 2012)

The CDIO approach starts with a definition of educational context that is closely aligned to engineering practice. It promotes learning in the context of professional practice, communicates the rationale and relevance of what students are learning, interconnects concepts and knowledge that build on each other, and increases retention of new knowledge and skills.

The ITLS is a flexible and dynamic teaching-learning system open to the changing demands of the world of work and the specialized and/or multi-disciplinary trends in the academe. It is a dynamic system aimed at realizing the ITLS objectives, with the following key components: 1) Course Delivery, which includes the identification of learning outcomes and experiences, workspaces, and faculty competence; and 2) Course Assessment and Monitoring, which includes student assessment methods and class supervision.

The course delivery component involves the process of designing integrated learning experiences by competent faculty within appropriate workspaces. The Faculty Competence component focuses on "underpinning knowledge", implemented through the Faculty Capacity Building Program. Assessment and Monitoring is the stage that corresponds to "checking" in the PDCA cycle, or the methods applied for ascertaining that course delivery has been either successful or in need of a review. Student assessment is the third component in the 3-wheel cycle that is course delivery and is aligned with learning outcomes and learning experiences. The main aim of monitoring delivery by faculty shall be for the faculty's growth and development.

In seeking to address Standard 10, Enhancement of Staff Teaching Skills, the USTP set up a Faculty Capacity Building System, which is a comprehensive system that seeks to capacitate faculty through training, supervision, constructive feedback, and evaluation. It aligns three programs so that the competencies for which the faculty are evaluated are the same competencies for which they are trained and supervised. These three programs are the following: 1) The Faculty In-Service Training Program; 2) The Instructional Supervision Program; and 3) The Faculty Evaluation Program.

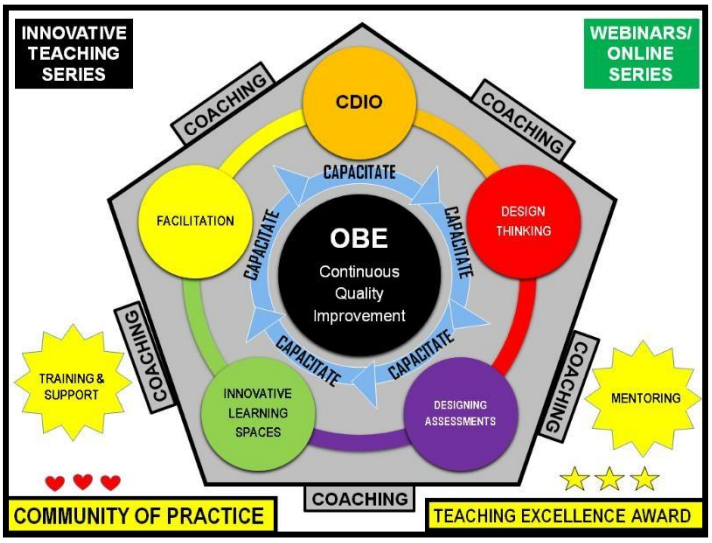
## II. CENTER FOR INNOVATIVE TEACHING AND LEARNING (CITL)

The Center for Innovative Teaching and Learning (CiTL) is an important enabling hub for achieving institutional goals by providing outstanding instruction and support for its new faculty and continuing professional development for its veteran and experienced faculty members. This shall enable the university to produce graduates that can compete globally, not only as employees but also as leaders and innovators in industries. TEMASEC Singapore has shared with USTP its innovative strategies in teaching and learning, which many top international universities have adopted and implemented. ASEAN integration, international accreditation, and globalization drive the university to produce graduates that can compete globally. USTP has also been a partner for five years with Singapore Polytechnic in the implementation of Learning Express, where the design thinking (DT) framework has been used to create and propose solutions to the community's problems. However, the use of CDIO and DT has been

limited to certain activities and employed by a few trained faculty. The need to institutionalize and have an enabling mechanism is called for.

This center will facilitate the integration of the disruptive innovation framework and paradigm (CDIO and design thinking) in the different curricular programs, which includes the development and support of the teaching and learning of innovation courses in engineering and other programs through capacity- and capability-building trainings of the faculty. It will provide a venue where effective educational strategies, best teaching practices, evidence-based practices, and pedagogy are shared among faculty members. Exemplary curricular programs and courses where educational technologies have been used or integrated into instruction will be shared with other HEIs.

For the realization of one of USTP's new administration's 7-point agenda, specifically the "Yearn for Excellence in Teaching and Learning," it is the aim of the center to be an enabling hub for achieving institutional goals, to manage as well as supervise the introduction and implementation of new pedagogies, and to start building the innovative teaching and learning ecosystems to produce quality graduates that are not only educated to support and work in an industry or company but also educated to become innovative entrepreneurs, innovators, and leaders. Specifically, CiTL as a faculty support will: 1) facilitate the integration of CDIO and design thinking in the different curricular programs, which includes the development and support of the teaching and learning of innovation courses in engineering and other programs through capacity- and capability-building trainings of the faculty; 2) provide the venue where effective educational strategies, best teaching evidence-based practices, and pedagogy are shared among faculty members; and 3) facilitate the review and design of the curriculum, courses, and programs to sustain and promote innovation. With the above, the Center's framework is presented here:




The Center's framework shows that the university will continually strive for excellence in instruction with outcomes-based education (OBE) as a method for curriculum design and teaching. The stated outcomes and objectives of the curriculum will be achieved if the faculty are provided with the opportunity to be capacitated and with several venues for capability-building in-service trainings. These in-service trainings include, but are not limited to, concepts

of CDIO, design thinking, facilitation, and designing assessments of learning and methods. However, the Center also believes that there must be follow-through or assistance that must be extended to the faculty after attending trainings or workshops. Thus, coaching and mentoring are programs that will ensure sustainability and a continuous drive for improvement in instruction. The online series and webinars are also provided for the faculty to also gain knowledge on evidence-based pedagogies through a short video highlighting some good practices for teaching university students.

Believing that excellent teaching must be recognized, the innovative teaching series is a year-round activity in the college where faculty will share their strategies and pedagogies for engaging students and their experiences using CDIO, design thinking, etc. in class. The Center is basically a faculty support center, and with its programs and services, the vision is to have a community of practice in USTP.

Table 1. The CiTL activity and its purpose

| ACTIVITY | PURPOSE |
|---|---|
| 1. Capacity- & capability-building Trainings for the Faculty for the Development and Support of the Teaching and Learning of Innovative Courses | Faculty In-Service Training Topics: 6-day Design Thinking Training (2 days per campus/group) 9-day Advancing Conceive Design-Implement- Operate (CDIO) (3 days per campus/group) 6-day Designing Assessments of Learning and Methods (2 days per campus/group) 3-session Discussion on Creating a Learning Environment that fosters Innovation 3session Training on Designing and Facilitating Group Work (1 day per campus/group) |
| 2. OBE, CDIO and Program Level Designing Assessments Training and Continual Quality Improvement (CQI) Planning & creation of Assessment Tools Training | This program includes a series of trainings and workshops for the identified instructors including Deans and Chairpersons.<br>Training Topics: Designing Courses (OBE), OBE, CQI, Program Level Assessment Tools Planning, Workshop and Writeshop for all the Focal Persons |
| 3. USTP Faculty Webinar or Online Series | Considering that some Faculty would like to learn by viewing some materials and learning from discussions, these videos are available online on the training topics, example, on designing effective and innovative courses, creating online quizzes, using instructional technologies etc. |
| 4. New Faculty Program (to introduce new faculty to the teaching community) | This program will actively engage our new faculty members on a number of topics including but not limited to, preparing to teach, university policies, the civil service matters, NBC 461 etc. |

| | |
|---|---|
| 5. Faculty Mentoring-Coaching Program (FMCP) | This program will include Instructional Supervision with Feed backing techniques and on using Faculty Evaluation to improve teaching for the Deans, Department Chairs, and Program Heads.<br>Activities for this program include a mentor-mentee 3Cs (checkpoint, concerns, celebrations) sessions which are basically professional development opportunities by organizing sessions on effective educational strategies, best practices teaching to faculty members; Training on the Mentoring-Coaching Skills; Sessions on Mentor-Mentee/Coach-Coachee; Training on Instructional Supervision for Deans, Department Chairs (includes discussions on how we can help the faculty, taking off from the Faculty<br>Performance Evaluation) |
| 6. Teaching Excellence Award | USTP will honor faculty members for their work with students, including the recognition of excellent mentors/coaches, tribute for the retirees, service awards |
| 7.Curriculum/Course/Program Review and Crafting | This program hopes to integrate innovation in some select courses. Thus, activities will be conducted to review the strategies used by Faculty in creating an environment that fosters innovative minds to look into which courses may be offered |
| 8. Innovative Teaching Series (Short Talks and Showcase of Excellent/Innovative Teaching and Reinvention) | This program is where the Center facilitates for a Faculty to share with colleagues his/her teaching practices in using CDIO, etc. This includes training on using the virtual learning environment, and on using technology in the classroom |

Prior to the implementation of the Center for Innovative Teaching and Learning (CiTL), the University of Science and Technology of Southern Philippines (USTP) applied as one of the CDIO International Collaborators during the March 2018 Regional Conference at Duy Tan University in Da Ning, Vietnam. With this, USTP is privileged to have participated in the workshops and conferences conducted by the CDIO committee, wherein invited institutions gathered to share experiences and ideas, review developments and CDIO implementation approaches, and participate in paper proposals, workshops, and roundtable discussions. Appropriately, part of the participating universities' responsibility as CDIO collaborators is to instigate an innovative teaching culture and lead the implementation of the CDIO curriculum with its corresponding principles, skill sets, and best practices in a student-centered classroom.

As part of USTP's commitment to CDIO, a CDIO-trained faculty member from the engineering department conducted 5-year longitudinal research on the software engineering course among 5th-year computer engineering students. The first four school years (from 2013 until 2018) were handled by the said faculty, while the final school year (2018–2019) was handled by both the CDIO-trained faculty member and another who has no background in CDIO; however, these faculty members shared the same instructional materials. The Software Engineering course would be taken in the 2nd semester of the 5th year level for Computer Engineering students. Through CiTL, the CDIO master trainer faculty member shared her innovative teaching strategies and experiences in handling the course leading to the industry-ready scheme for the students with the USTP community under the Innovative Teaching Series program to inspire and encourage fellow instructors and professors.

## III. REFLECTIONS AND BURNING QUESTIONS ON EXPERIENTIAL LEARNING ACTIVITY FOR SOFTWARE ENGINEERING COURSE LEADING TO TRANSITION INTO WORKFORCE

One of the major challenges in implementing the CDIO principles and strategies with the 5th year Computer Engineering students for their Software Engineering course was how they would be excited about the concepts in the classroom and apply them to real-world situations, such as helping them solve the problem of their client through software development. In 2013, the University of Science and Technology of Southern Philippines (USTP) introduced outcome-based education (OBE) to be implemented in all engineering courses at the university. In 2014, the university sent a group of faculties to attend a series of seminars and workshops on CDIO conducted by Temasek and Singapore University as a tool to implement the OBE in the university. The purpose of the Software Engineering course is to expose students in Computer Engineering to real-world problem solving in the context of software development. Students will be required to describe and demonstrate the requirements and specifications of the system, design methods, reliability and safety, validation and verification, prototypes, maintenance, project planning, and quality assurance. The course description was based on the course outcome namely (1) Plan and deliver an effective software engineering process based on knowledge of widely used development lifecycle models to outline the problem; (2) Make an effective use of UML along with the design strategies such as creating a software architecture, specification, separation of concerns and design patterns for the efficient system solutions; (3) Formulate and implement a testing strategy for software system, program verification and validation, and a thorough software testing such as unit testing, functional and non-functional testing before employing to the client; (4) Employ group working skills including general organization, planning, time management, and negotiation in the intergroup and to their client. The course outcomes were the core guidelines for the activities given to the students in the classroom.

The purposes of this study are the following: (1) To apply the CDIO framework as a tool to implement the OBE in the Software Engineering course. (2) The students are given autonomy to design and develop a software system using the methods and principles of software engineering according to the requirements of the client. (3) To determine whether the implementation of CDIO's experimental learning activity in the software engineering course is effective in helping the students in real-world production.

### *A. Method and Approach*

In the first week of the class, the students were given the requirements to finish the course and the schedule of activities. Table 2 shows the requirements of the course, and Table 3 shows the schedule of activities. The students will be grouped by 3–4 members. They were given autonomy to look for a client that involved software development to solve their client's problem.

Table 2. Requirements for completion of the course

| | Requirements | |
|---|---|---|
| 1 | Hardbound of the final manuscript | 2 copies |
| 2 | Video Tutorials | It takes 20 minutes or more. How the system works |
| 3 | System Manual | 2 copies. Instruction on how to use the system |
| 4 | Tarpaulin Design | 3 x 4 ft size |
| 5 | Extension and Research Format | Refer to the given research format |
| 6 | Copyright of System at IPO | Refer to the format |
| 7 | Group logo and its meaning | |
| 8 | System logo and its meaning | |
| 9 | CD-disk | 2pcs (All the requirements will be saved: Manuscript, Video tutorial, system Manual, Working system Program, Tarpaulin design, Research & Extension Format) |

Table 3. Schedule of Activities

| DATE | ACTIVITY |
|---|---|
| JUNE – OCTOBER (1st Semester) | From Project Management (System Analysis and Design) Course: You already searched for your client; interviewed; created the initial system design. |
| November to December | Submission of the requirements from the client<br>The system flow design, The architecture of the system |
| 3rd Week of January | Partial Checking of Video Tutorials, system Manuals, Tarpaulin Design, Group Logo, and system Logo |
| 4th Week of January | Partial Checking of PowerPoint presentation, Software system, and manuscript |
| January 29 - 31 | Follow-up checking / Presentation |
| February | Congress Oral Presentation |
| 2nd Week of February | Final checking of Video Tutorial, System Manual, Tarpaulin, Software system, and manuscript |
| 3rd Week of February | Final checking of Extension & Research form, Copyright form |
| 4th Week of February | Final Defense with the panel and your client |
| 2nd Week of March | Final submission of all the requirements. Lacking requirements = INC |

The schedule of activities was monitored strictly by the faculty, under the supervision of the chairman of the Department of Computer Engineering. The activities needed to be extended to cater to the whole class, but this was done without disrupting the other classes. During the

follow-up checking of the software system, the subject adviser invited software developers, programmers, and fellow faculty to form a panel to analyze the methods and principles used in the software system. These helped the students broaden their skills and knowledge in software development. Tables 4a and 4b show the criteria for the evaluation of the system project by the students.

Table 4a. Criteria for the Follow-up Presentation

| CRITERIA | RATING (100%) | COMMENTS |
|---|---|---|
| ***Presentation (15%)***<br>Ability to outline a topic; Language skills; Use of media | | |
| ***Content (35%)***<br>Knowledge of their subject area and related fields: Ability to explain their work based on their client; Documents requirements (Graphs, ERD, forms, etc.) | | |
| ***Design and Methodology (35%)***<br>Well-designed plan and data collection methods, Variables, and Controls defined, Appropriate and Complete; Functional icons, controls; Clear and focused-purpose | | |
| ***Flexibility of the Student (15%)***<br>Answer questions, discussions and transfer of ideas | | |
| ***Grade*** | | |

Table 4b. Criteria for the Final Presentation

| CRITERIA | RATING (100%) | COMMENTS |
|---|---|---|
| ***Presentation (15%)***<br>Ability to outline a topic; Language skills; Use of media; Knowledge of their subject area and related fields; Ability to explain their work based from their client | | |
| ***Design and Methodology (15%)***<br>Well-defined plan and data collection method; Variables, controls defined; Appropriate and complete; Clear and focused-purpose; Documents requirements 9graphs, ERD, forms, etc) | | |
| ***System Outline (25%)***<br>Systematic outline of forms; the Color combination is well-blended; Menu selection is visible and not repeatable; System design is visually articulate | | |
| ***System Functionality (45%)***<br>Functional icons and controls; Testing cases (validation & Verification); Able to use other end-user devices; Data collected is correctly manipulated(client's requirements); Security of data; Processing of pages is working and efficient | | |
| ***Grade*** | | |

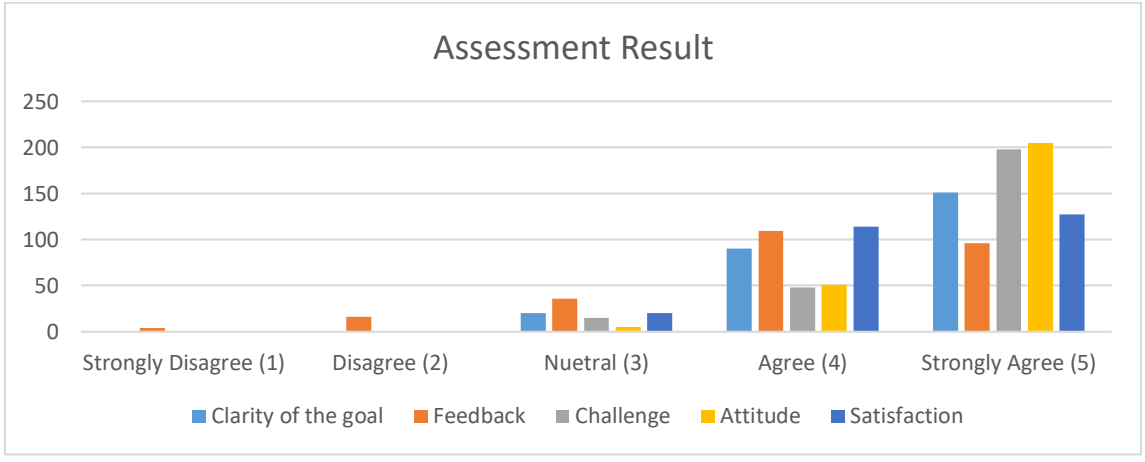
During the follow-up presentation and final presentation with the invited panels and clients, the students were asked deep reflections and burning questions regarding their system project. A group discussion was conducted to assess how well the activities improved their learning outcomes, and the constructive feedback really matters to help the students improve their work and experiences. The answers represented whether they really understood what they were doing, and it was assessed by a questionnaire with a 5-point Likert scale (1= strongly disagree, 2= disagree, 3= neutral, 4 = agree, 5= strongly agree) to measure some aspects: clarity of the goal, feedback, challenge, attitude, and satisfaction. Table 5 shows a sample of deep reflection and burning questions.

Table 5. Sample deep reflection and burning questions.

| |
|---|
| 1. How did you enjoy the project? |
| 2. How did you learn the different software methods and processes? |
| 3. How easily do you handle your client's requirements? |
| 4. How did you feel that you almost completed your project? |
| 5. How was your experience in making your project? |
| 6. How did you manage to work with your groupmates? |
| 7. How was the feeling of your client when you introduced your system? |
| 8. How did you manage the pressure? |

### B. Results

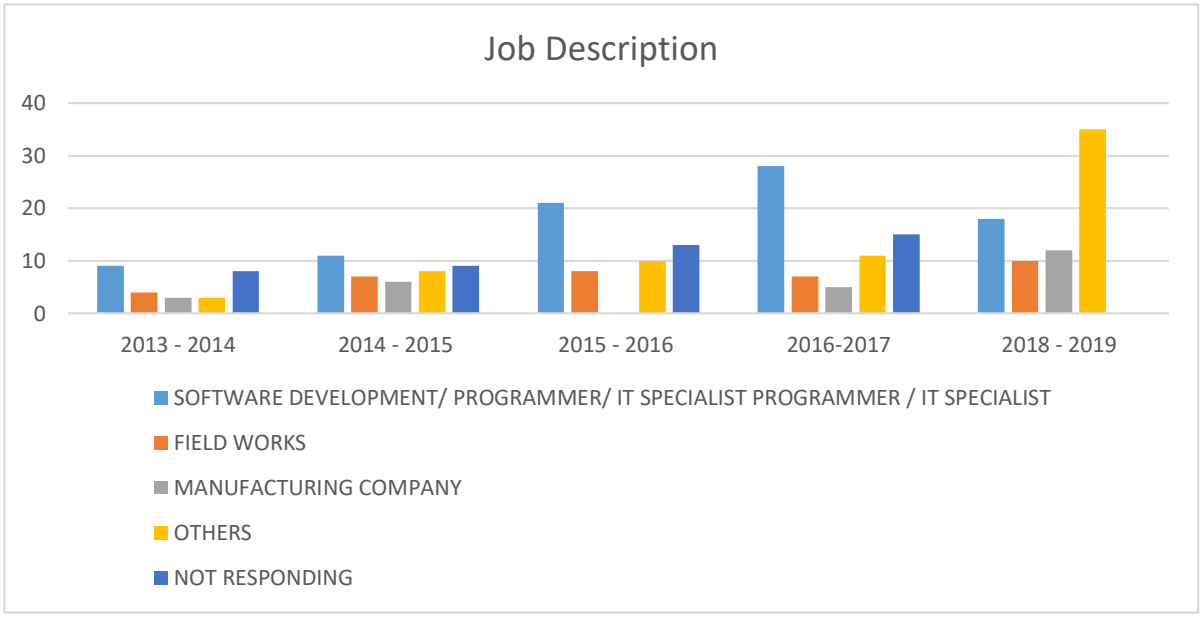
The deep reflection and burning questions activities were repeated yearly for 5 years with continuous revisions for different computer engineering students who were taking software engineering. The outcomes of the implementation of CDIO experiential learning activities improved the faculty's handling of the course by facilitating classroom activities to help the students undergo the activities that can help them handle real-world activities and client-based problem-solving. In return, the students learned how to handle pressure and were ready to embrace challenges. Recurring consultations and feedback also created a good professional relationship between the students and the faculty. Graph 1 shows the result of the assessment aspects during their presentation. The correspondents consist of 261 students from SY 2013 to 2019, in 5 years. The same students were asked about their job position after graduation.




Graph 1. The assessment result of 5 aspects for the system project of 261 students in 5 years

The graph signified that the students were focused and embraced the learning outcomes while using the tools for experiential learning activities through conducting their software system project. There was a higher percentage responding of “Strongly Agree”, it means that (1) the students knew the goal of their project; (2) feedbacks would help them to improve their project; (3) the activities would challenge their understanding and skills to engage in the project; (4) the activities helped to develop and improve their attitude towards works and individuals; (5) satisfied of the results of their project.

Another assessment to determine the effectiveness of the implementation of experiential learning in the classroom for the software engineering course was tracking the work histories of the students after they graduated and landed a job. Graph 2 shows the number of respondents and their jobs after graduation.




Graph 2. The result of the graduate tracer (2013-2019) with its job description.

Graph 2 indicates that the graduates of the Bachelor of Science in Computer Engineering were interested in software development or in information technology (IT) jobs. Some graduates were also interviewed about how they got the job. Answers included, “The activities in the software engineering course helped me furnish my skills”, “It helped me on how to handle different clients”, “I am immune to the pressures already”, “SE experience taught me how”, and “The SE learnings I got guided me on my career directions.”

Some of the career options for future Computer Engineers are Software Engineering, Software Development. Data Analysis, Database Administration, and System Administration. The faculty who handled the subject believed that the course is one of the key course indicators in the curriculum mapping of the program.

## CONCLUSIONS

As conclusion, it can be stated that the implementation of CDIO experiential learning activities, most notably the activity known as "deep reflection and burning questions," has shown a significant improvement in terms of facilitating classroom activity for software engineering students. The outcomes of the assessment aspects that took place during the students' presentation, as well as the tracking of the students' work histories after they graduated, show that the students were focused and engaged in the project, which resulted in their preparedness to accept challenges and handle real-world activity and client-based problem solving. Regular opportunities for consultation and feedback sessions were another factor that contributed to the development of a constructive and professional relationship between the teachers and the students. Graduates have benefited from the successful use of experiential learning in the classroom as it has assisted them in the development of their abilities, assisted them in dealing with a variety of clientele, and assisted them in their professional choices. These findings show that experiential learning, particularly the implementation of CDIO, is an effective method for enhancing the knowledge and abilities of students as well as preparing them for future employment opportunities.

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